

## Ch 4 Notes C Block.ink

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CH<sub>4</sub> electrons

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Ch 4 electrons

Rutherford's Atomic Model  
↳ solar system Model

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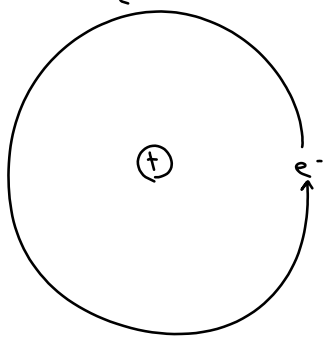
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Ch 4 electrons

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e<sup>-</sup> orbit the nucleus

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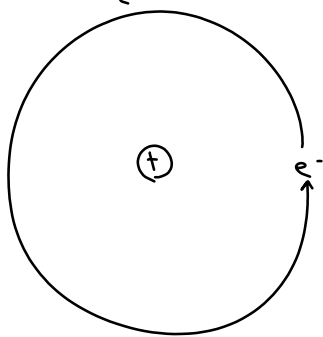
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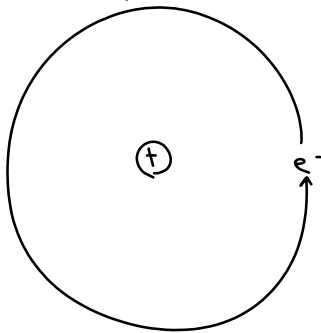
Flaw:



Ch 4 electrons

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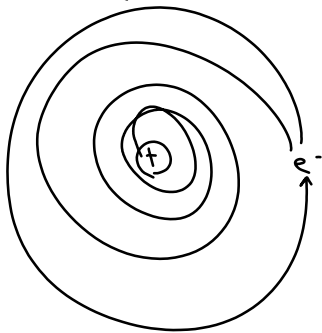
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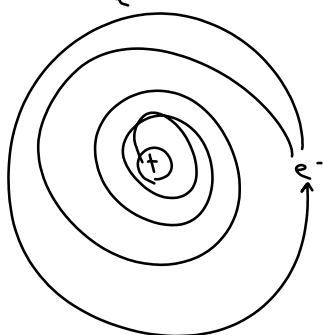
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Ch 4 electrons

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Also Doesn't Explain chemical Reactivity



## Ch 4 Notes C Block.ink

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waves - how E is transmitted

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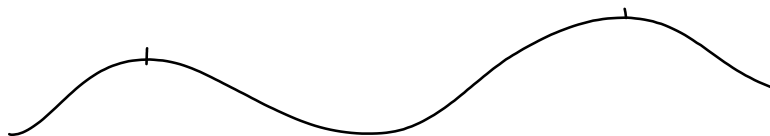
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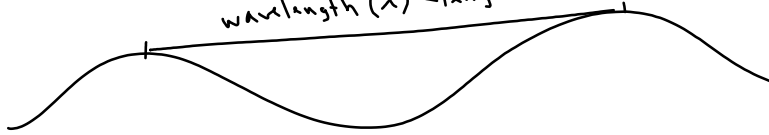


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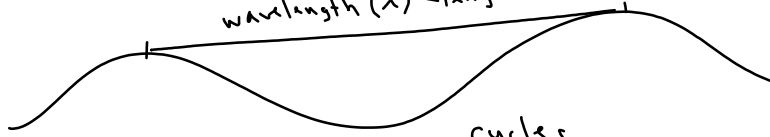


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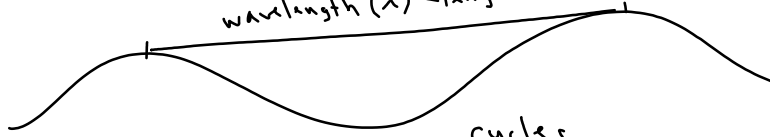


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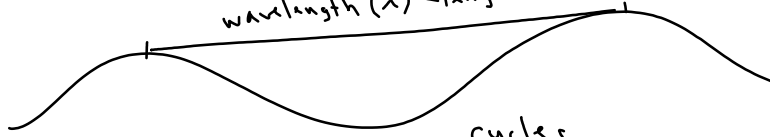


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inverse prop

Early 1900's Max Planck

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metal

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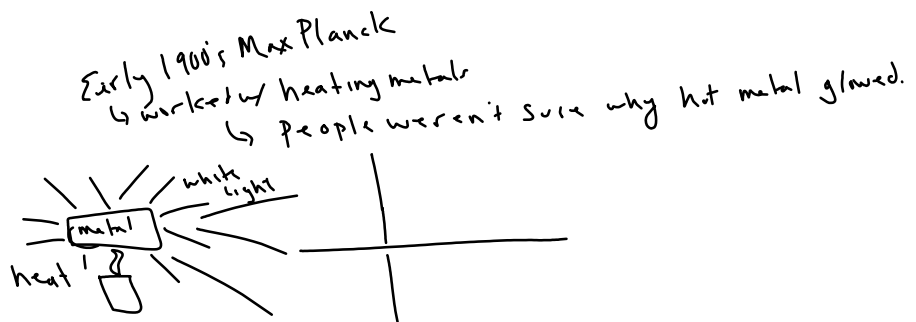
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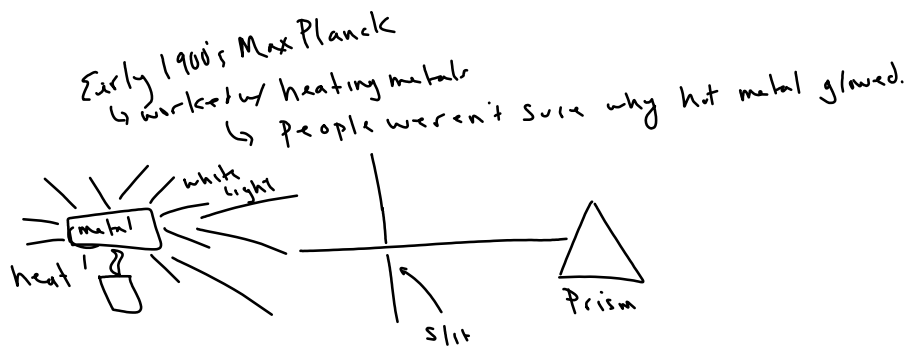
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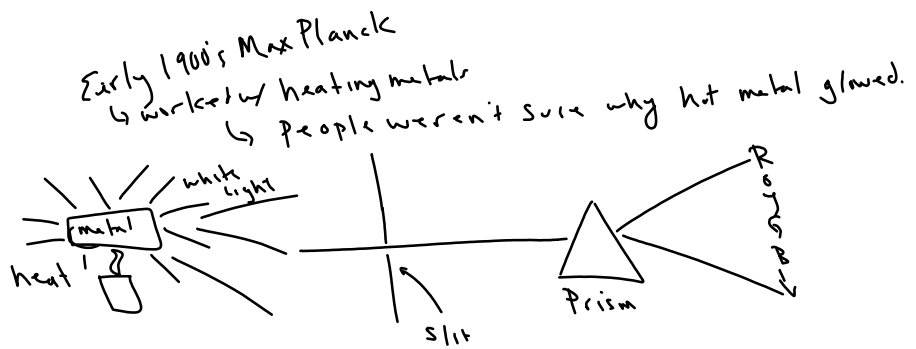
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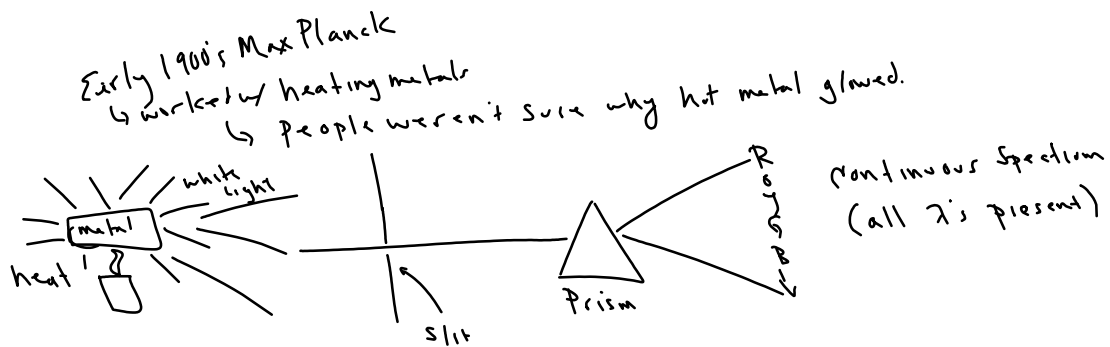
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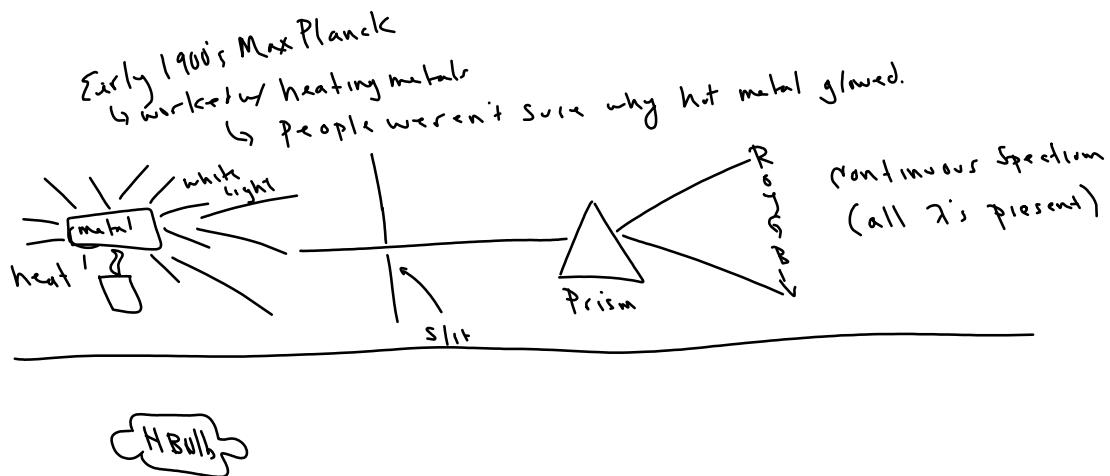


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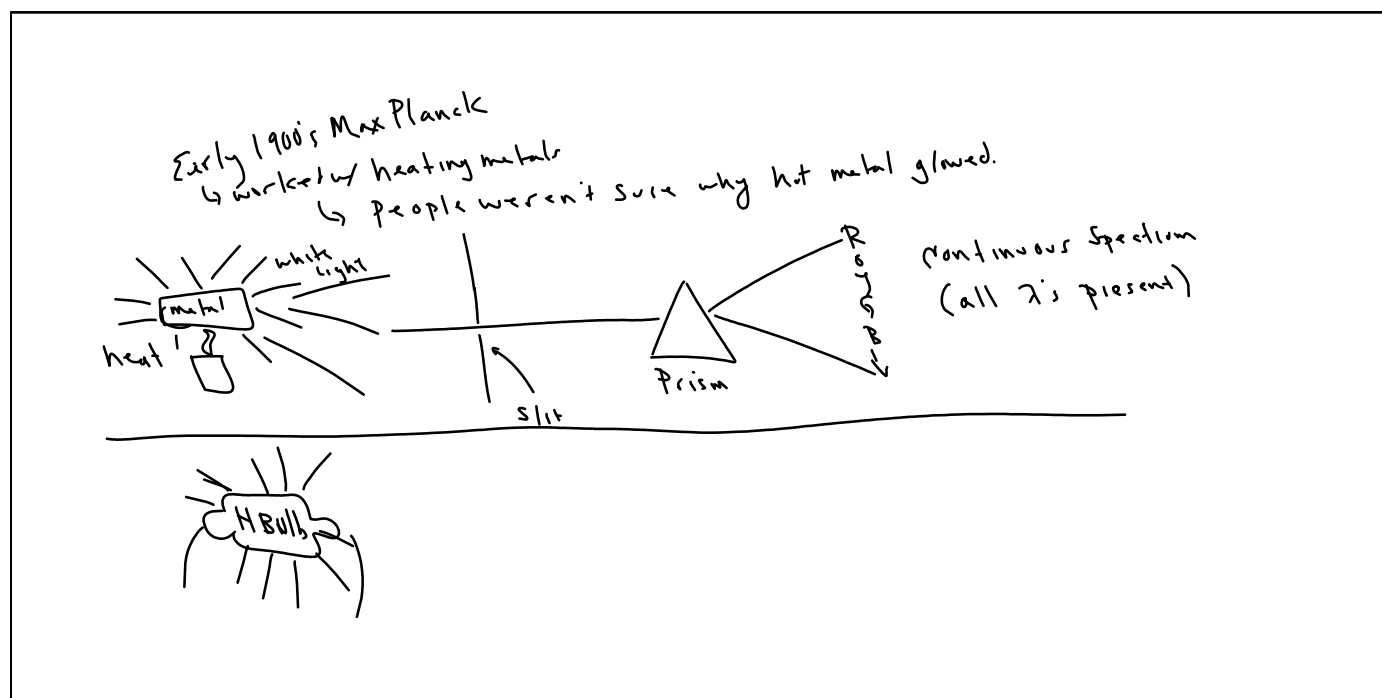
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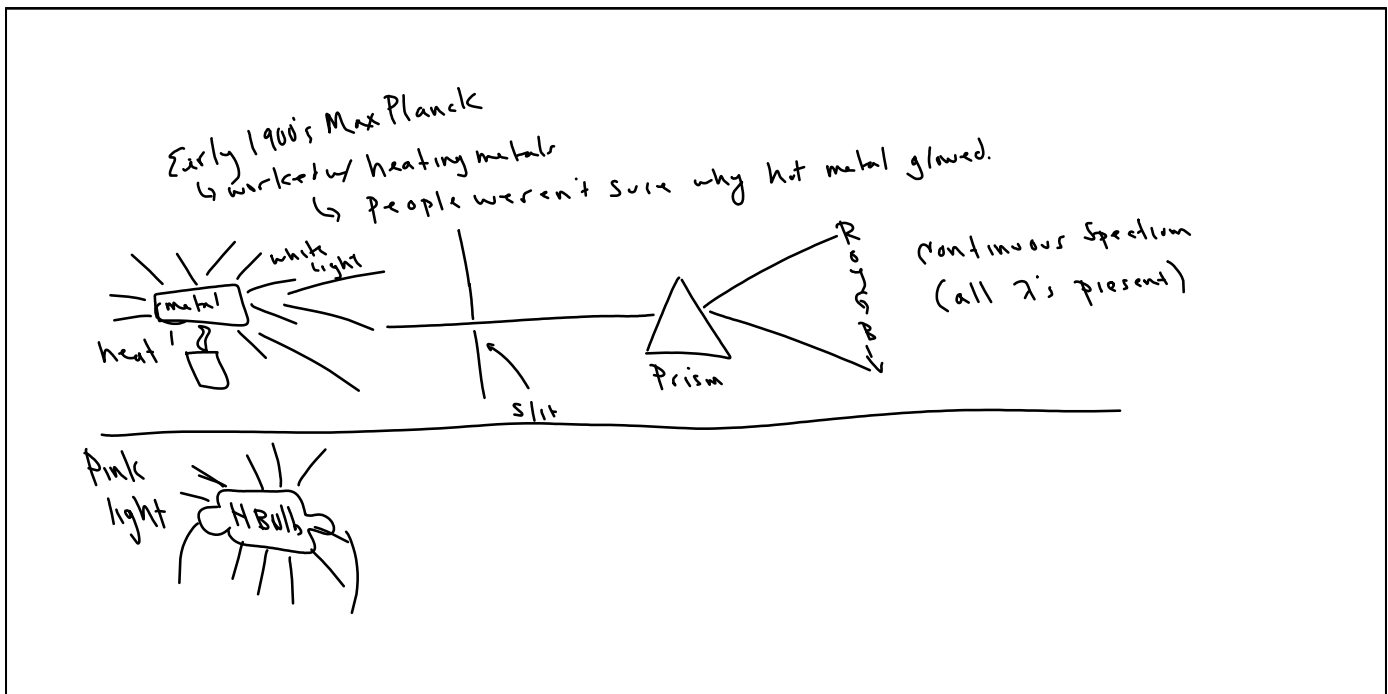


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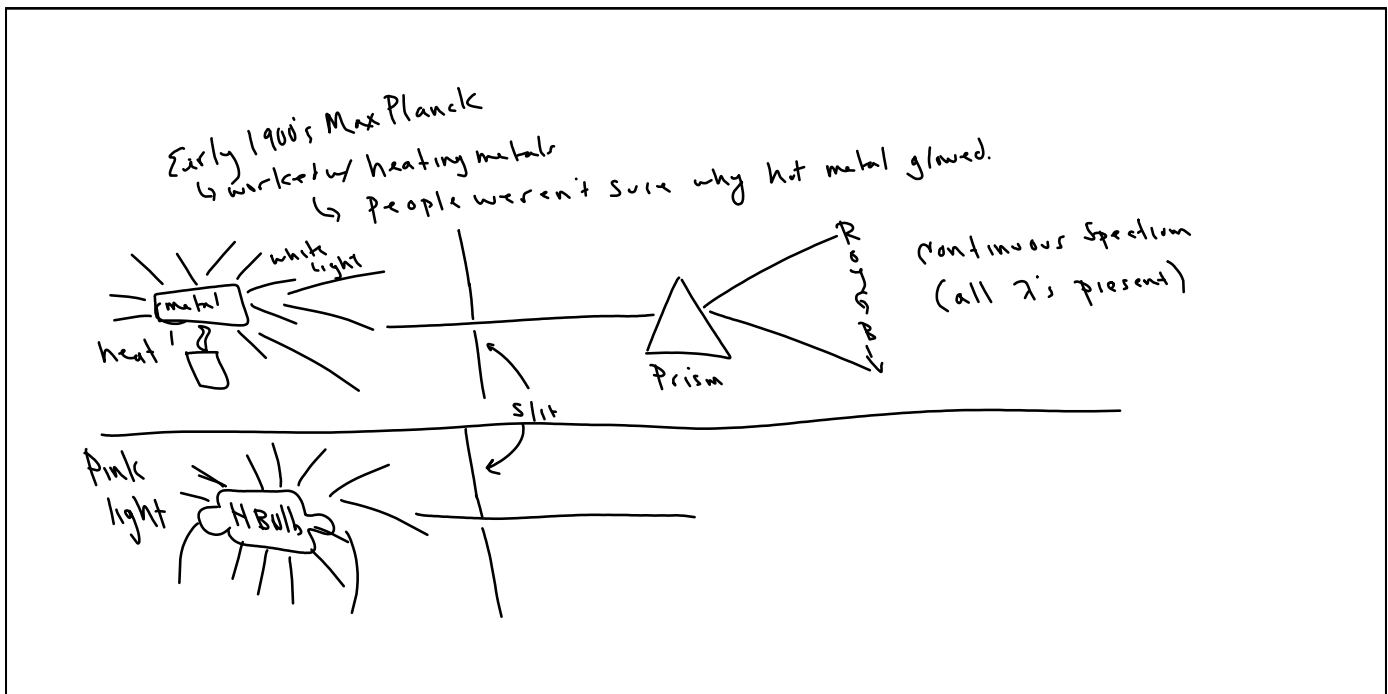


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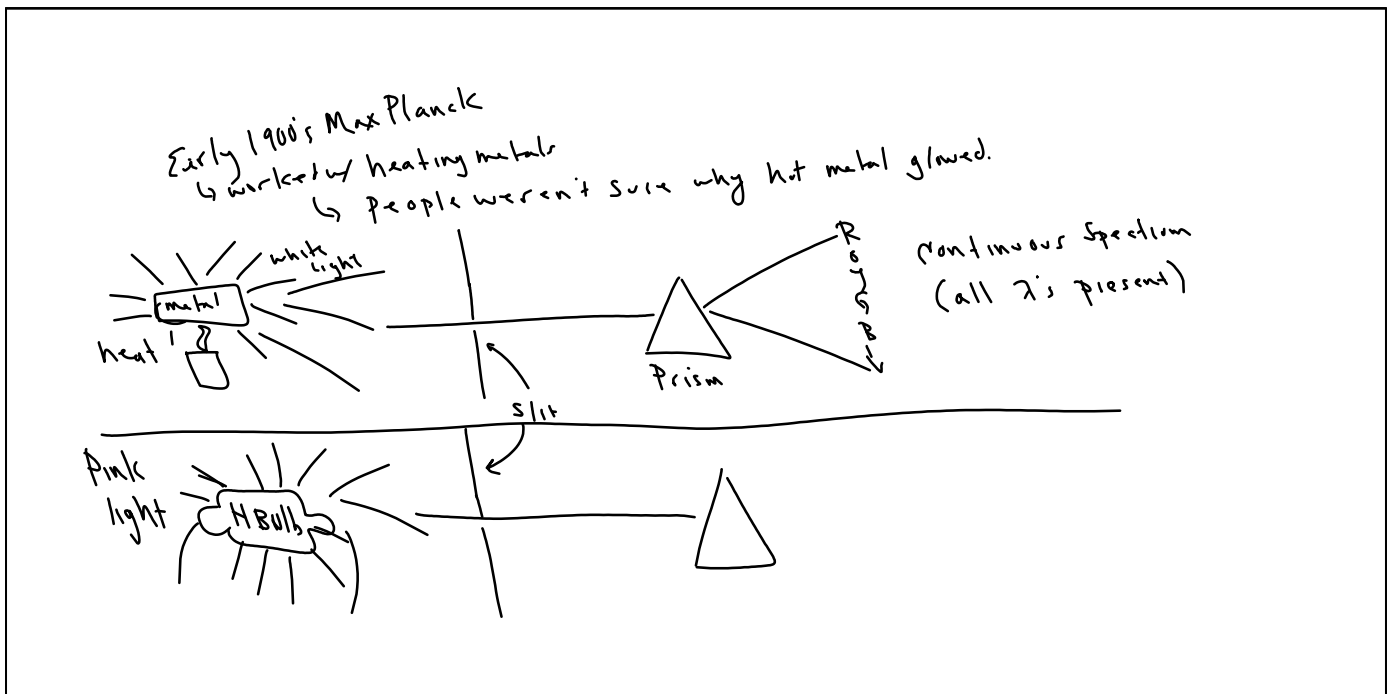
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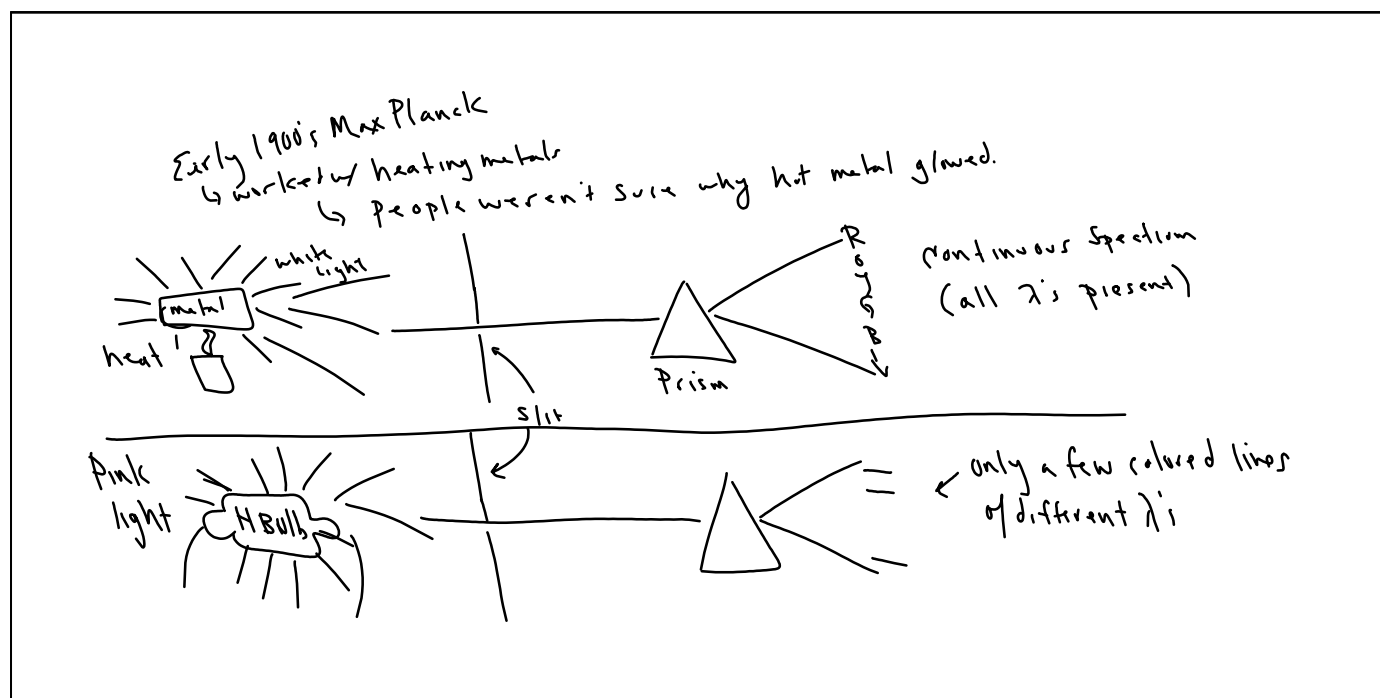


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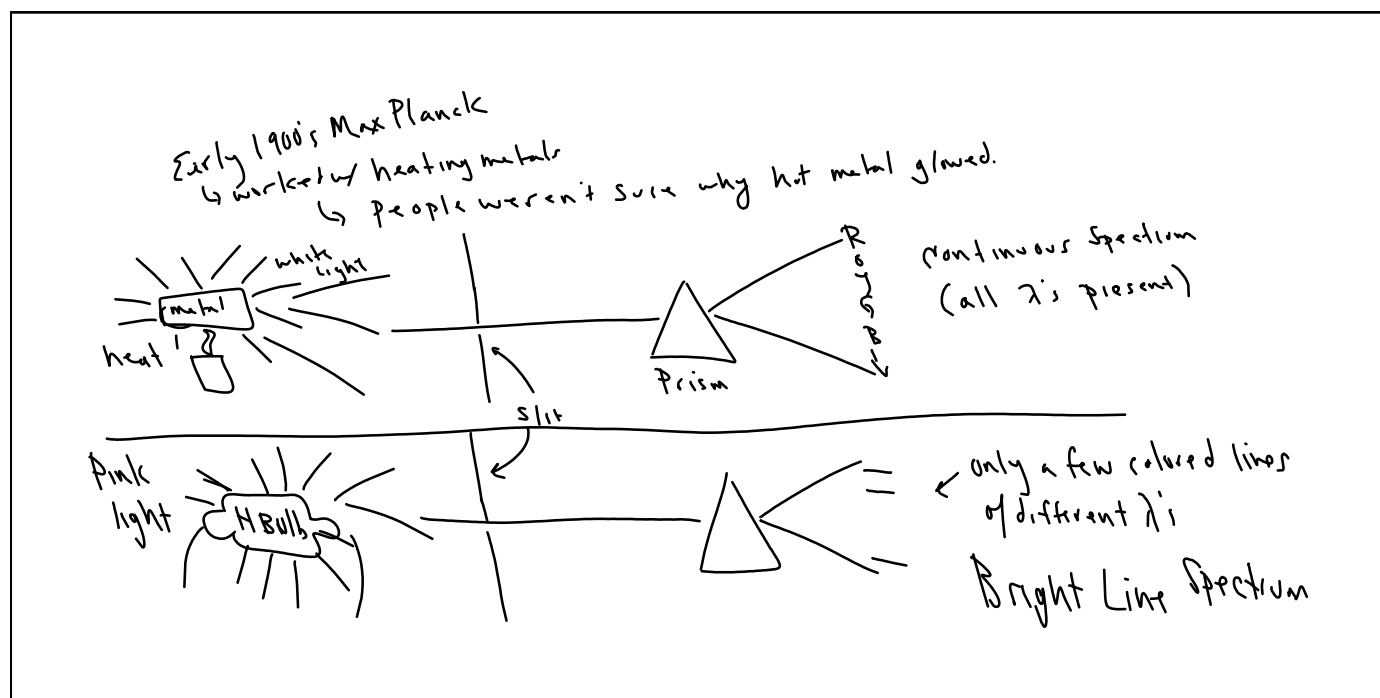




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Planck's Findings

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1. Hot Matter didn't lose E continuously

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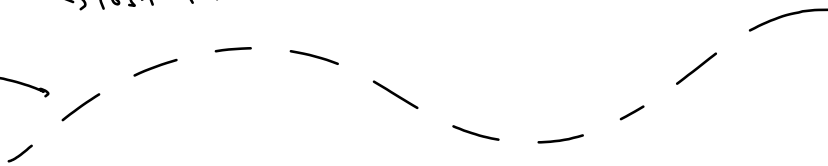
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Energy behaves like Matter  
B/c it comes in packets

3. Each line in the BL Spec Represents  
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Model of the H atom

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↳ Proposes that atoms are Quantised b/c the only allow certain E values.



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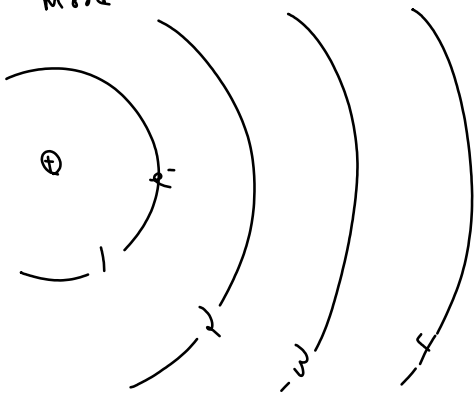
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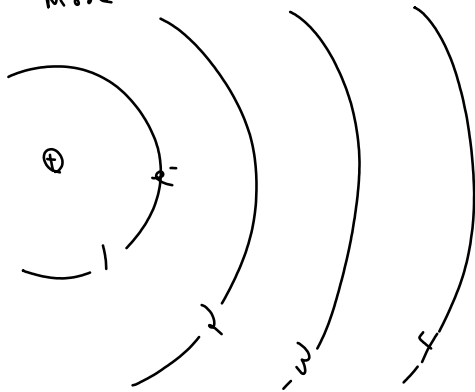


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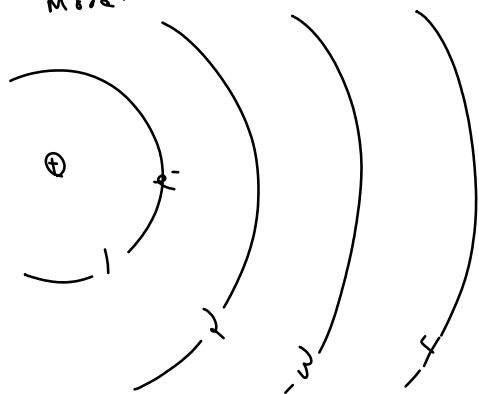
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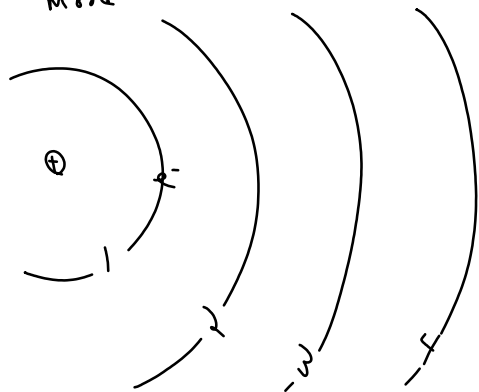
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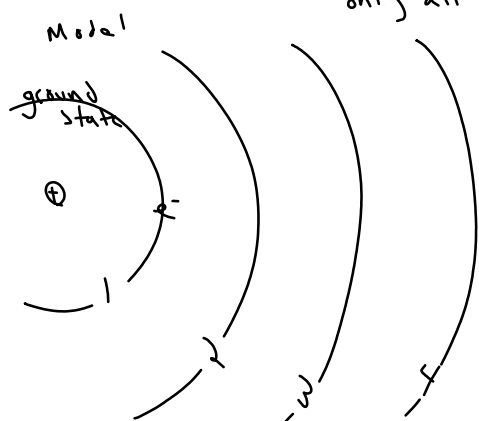


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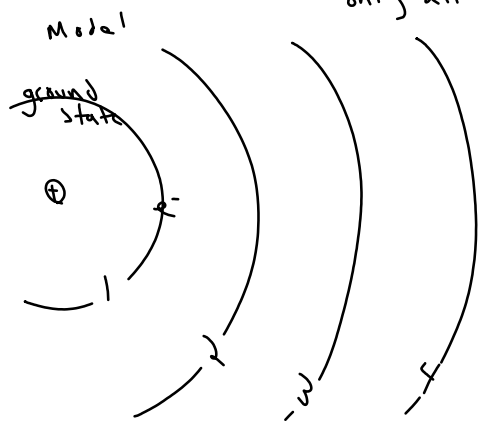
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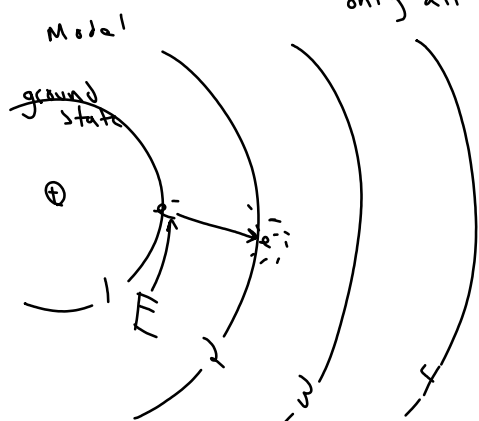
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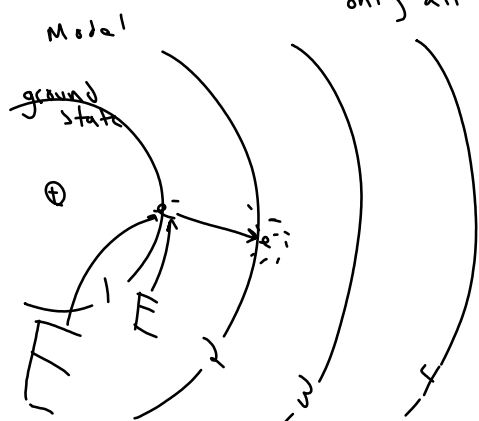
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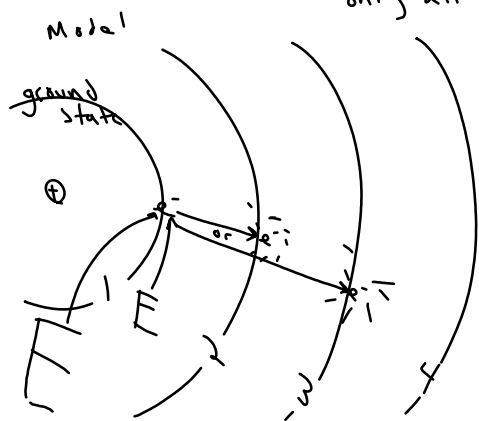
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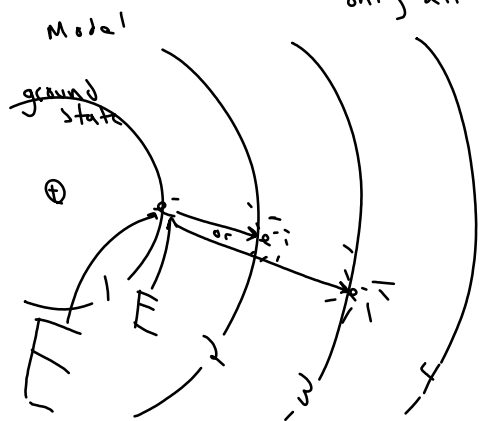
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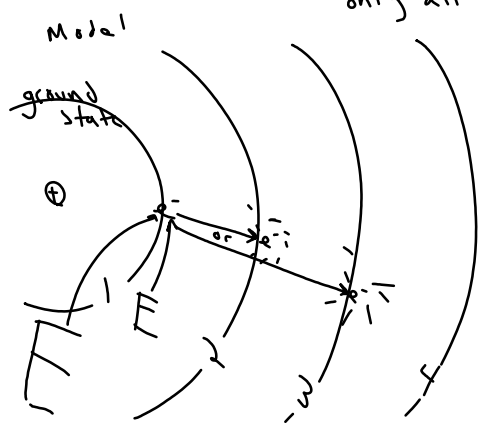
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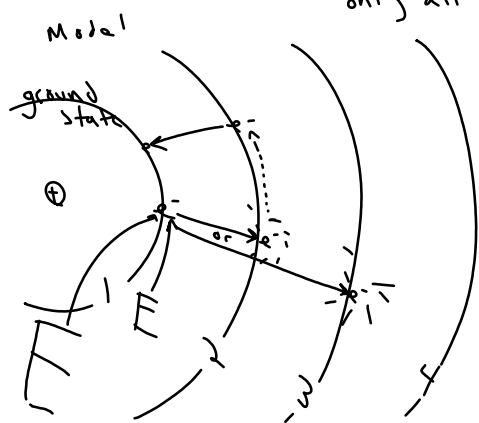
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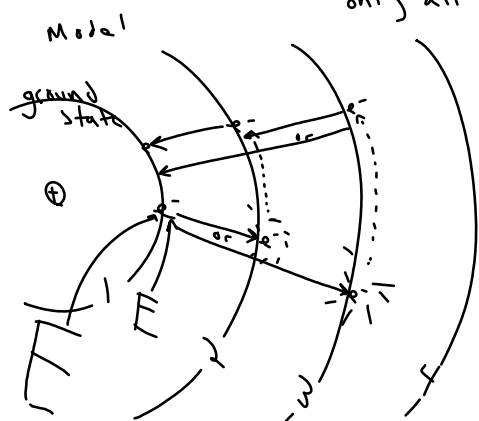
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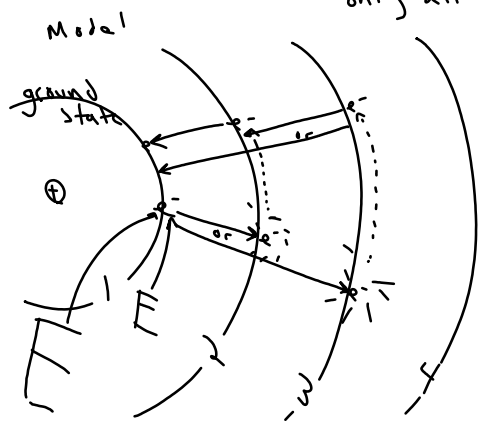
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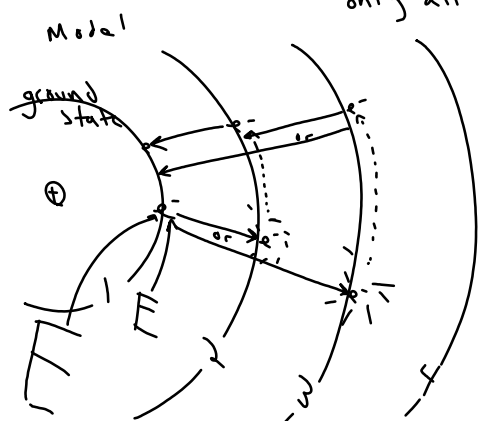
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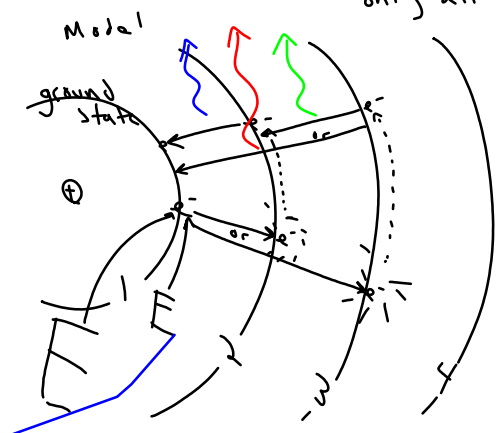
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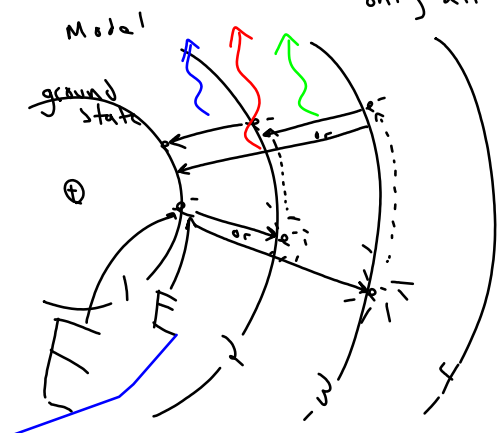
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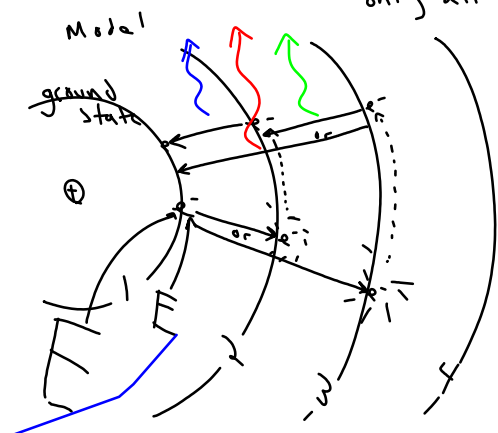
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↳ These  $\lambda$ 's are lines in the spectrum!



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E-levels in

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Also No explanation of chemical reactivity

(1923 Louis de Broglie)

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1923 Louis de Broglie  
↳ suggests  $e^-$  behave like waves



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Proven when comparing diffraction patterns of X-Rays to  $e^-$

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X-Ray diffraction

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X-Ray Bulb

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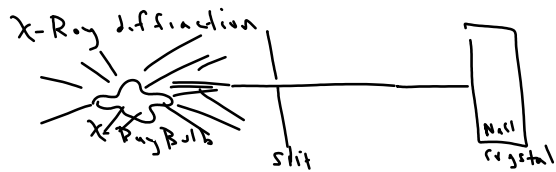
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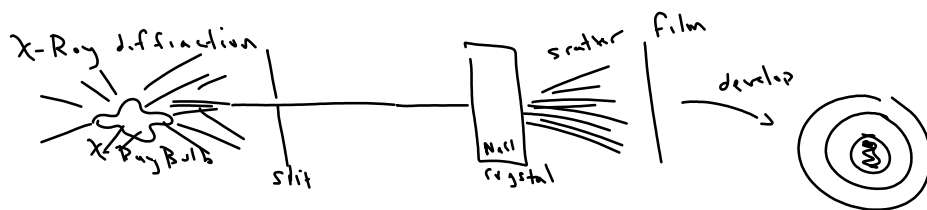




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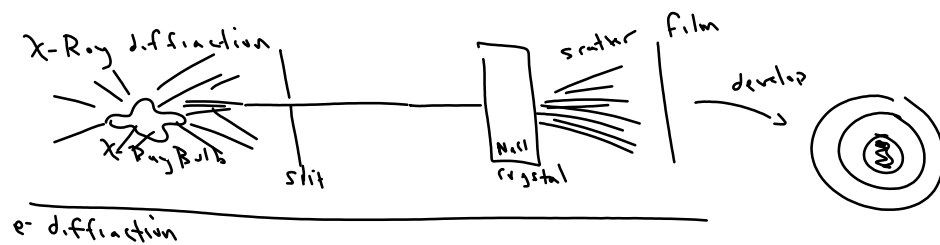
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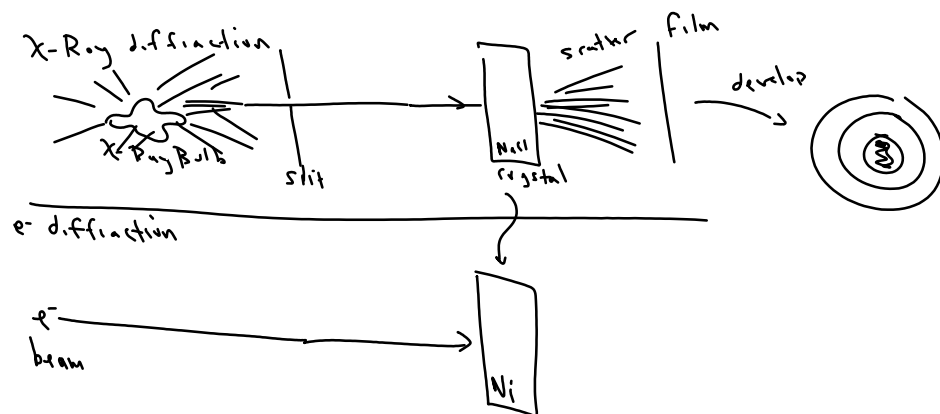
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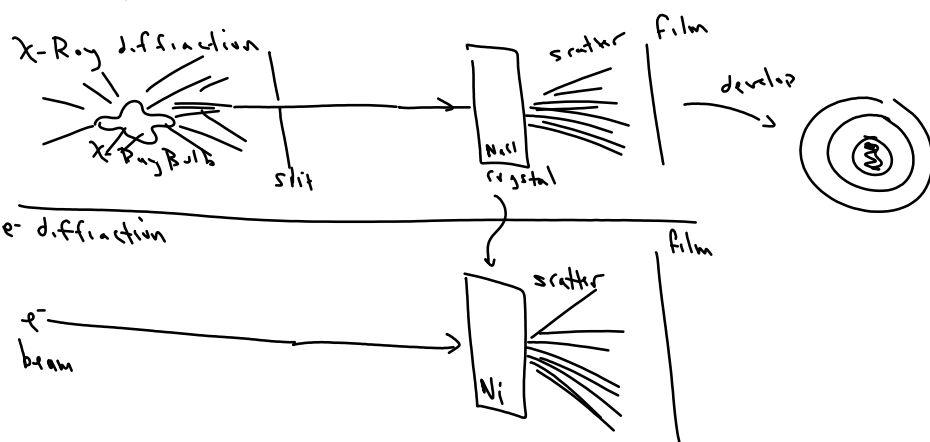
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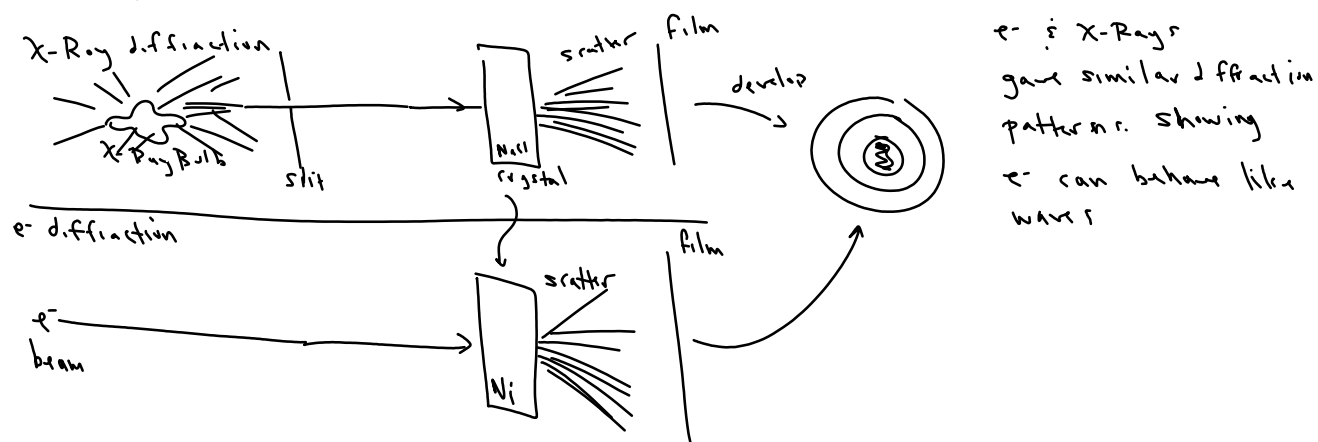
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## Ch 4 Notes C Block.ink

1923 Louis de Broglie

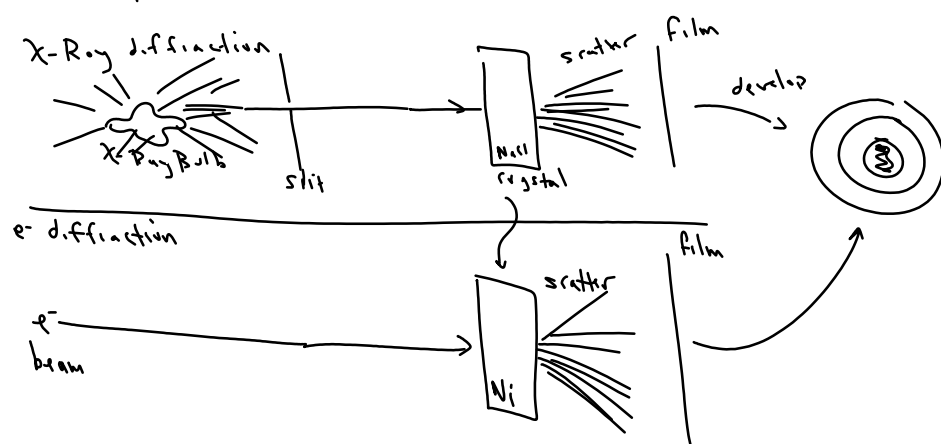
↳ suggests  $e^-$  behave like waves  
Proven when comparing diffraction patterns of X-Rays to  $e^-$



## Ch 4 Notes C Block.ink

1923 Louis de Broglie

↳ suggests  $e^-$  behave like waves  
Proven when comparing diffraction patterns of X-Rays to  $e^-$



$e^-$  & X-Rays  
gave similar diffraction  
patterns. showing  
 $e^-$  can behave like  
waves

Matter acts like E

## Ch 4 Notes C Block.ink

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Key People  
de Buglia -

## Ch 4 Notes C Block.ink

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key people

de Broglie - wave-particle duality



key people

de Broglie - wave-particle duality  
↳ behave like waves + particles

## Ch 4 Notes C Block.ink

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key people

de Broglie - wave-particle duality  
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Schrödinger

key people

de Broglie - wave-particle duality  
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Schrödinger - developed a wave Eqn that described wave behavior

key people

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### Key People

de Broglie - wave-particle duality  
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Schrödinger - developed a wave Eqn that described wave behavior which he applied to  $e^-$ 's

Heisenberg - Uncertainty Principle - we cannot simultaneously know where an  $e^-$  is & how fast it's going, only the space w/ the highest chance of finding an  $e^-$

### Key People

de Broglie - wave-particle duality  
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Heisenberg - Uncertainty Principle - we cannot simultaneously know where an  $e^-$  is & how fast it's going, only the space w/ the highest chance of finding an  $e^-$   
probability

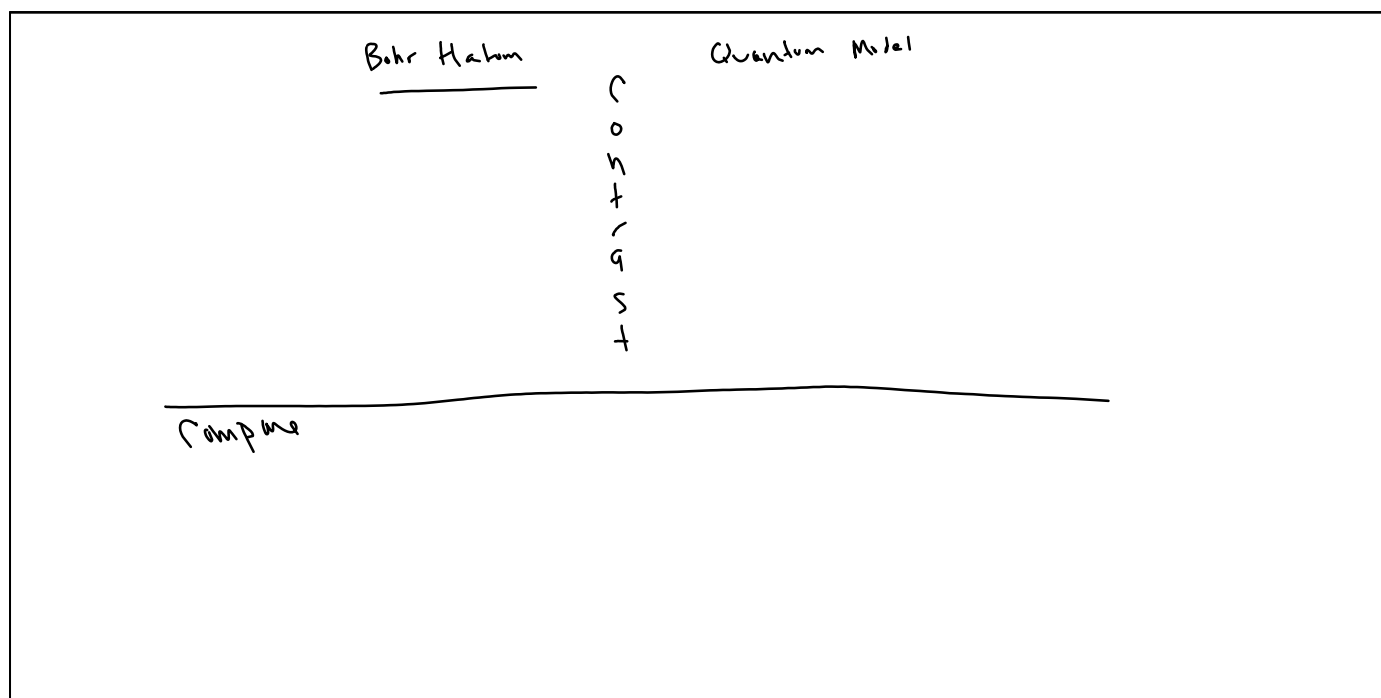
## Ch 4 Notes C Block.ink

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Bohr Model

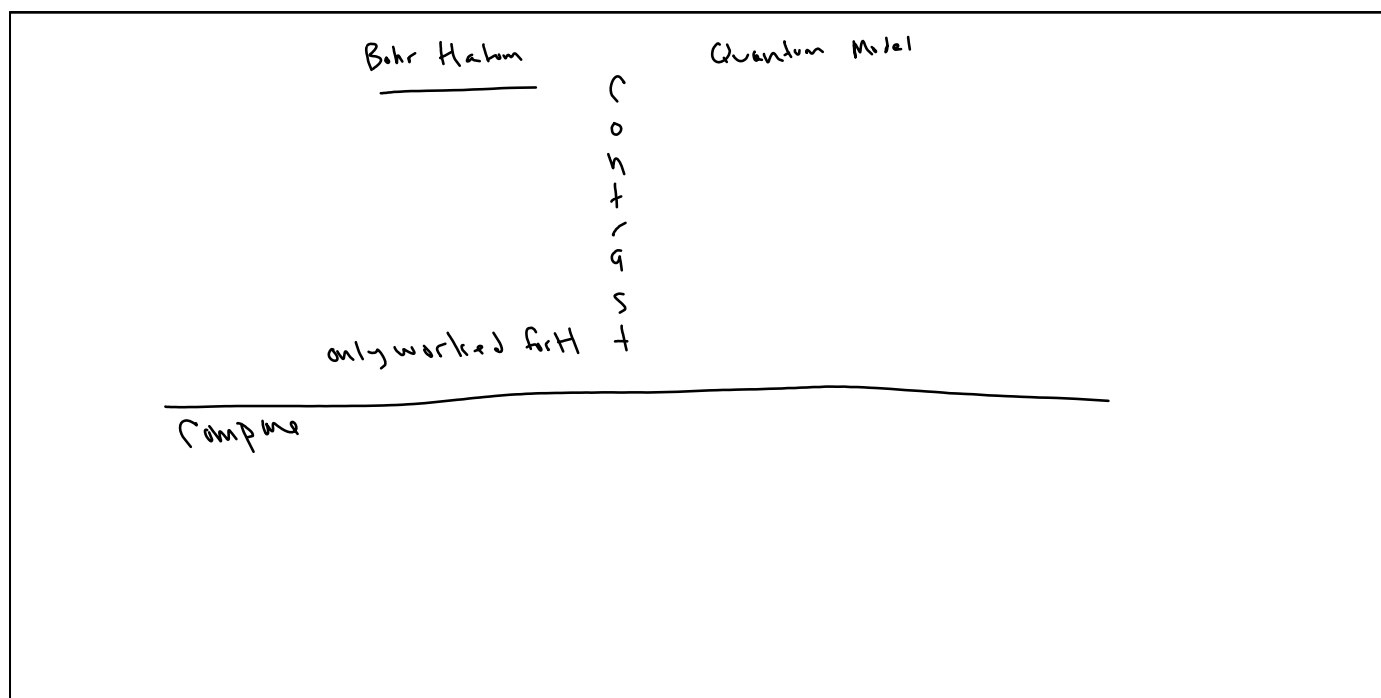
Electron  
Orbit





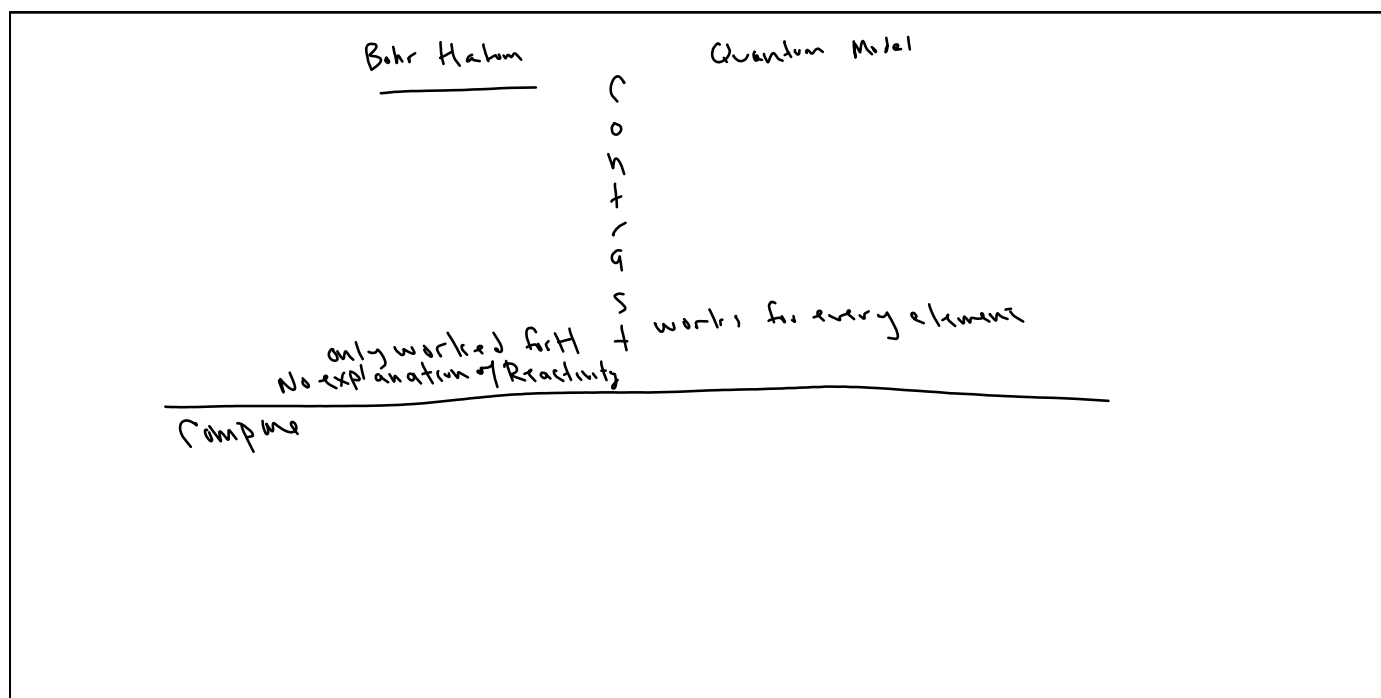
## Ch 4 Notes C Block.ink

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## Ch 4 Notes C Block.ink

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## Ch 4 Notes C Block.ink

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<u>Bohr Model</u>		Quantum Model
	C	
	O	
	H	
	+	
	/	
	g	
	S	
only worked for H	+	works for every element
No explanation of Reactivity		does explain Reactivity
Complete		

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only worked for H	+	works for every element
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Compare	<u>In Both models, <math>e^-</math> can absorb <math>E</math>, jump to a higher <math>E</math> level, and fall back to lower levels Releasing light</u>	

<u>Bohr Model</u>		<u>Quantum Model</u>
$e^-$ in 2D orbits	$\begin{matrix} \text{C} \\ \text{O} \\ \text{H} \\ \text{+} \\ \text{C} \\ \text{H} \\ \text{S} \end{matrix}$	
only worked for H No explanation of Reactivity	+	works for every element does explain Reactivity
<hr/>		
Compare	In Both models, $e^-$ can absorb $E$ , jump to a higher $E$ level, and fall back to lower levels Releasing light	
	1st $E$ level is the same dist from nucleus	

<u>Bohr Model</u>		Quantum Model
$e^-$ in 2D orbits	C o n t i n g	$e^-$ in 3D orbitals
only worked for H No explanation of Reactivity	S	works for every element does explain Reactivity
<hr/> <p>Compare <u>In Both models</u>, <math>e^-</math> can absorb E, jump to a higher E level, and fall back to lower levels Releasing light</p> <p>1st E level is the same dist from nucleus</p>		

### Bohr Model

$e^-$  in 2D orbits  
can pinpoint  $e^-$

$e^-$  are particles

only worked for H  
No explanation of Reactivity

### Quantum Model

C  
O  
N  
T  
S  
G  
S  
+  
 $e^-$  in 3D orbitals  
can't exactly locate  $e^-$

$e^-$  are waves

works for every element  
does explain Reactivity

---

Compare In Both models,  $e^-$  can absorb  $E$ , jump to a higher  $E$  level,  
and fall back to lower levels Releasing light  
1st  $E$  level is the same dist from nucleus



Pairs of QM

Pauli's QM  
1. Principle Quantum #

Parts of QM

1. Principle Quantum # ( $n$ )  
↳ tells you the E-level  $\epsilon$ 's are in

Parts of QM

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2 angular momentum Q #

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3. Info about orbitals <u>orbital</u>	# of parts to orbital (Sub orbitals)	# of $e^-$ in sub <u>          </u>	total # of $e^-$ <u>          </u>	Shape <u>          </u>
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Parts of QM

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3. Info about orbitals	# of parts to orbital (Sub orbitals)	# of $e^-$ in sub	total # of $e^-$	Shape
<u>orbital</u>				
s	1	2	2	sphere

## Parts of QM

1. Principle Quantum # ( $n$ )  
 ↳ tells you the E-level  $e^-$ 's are in  
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3. Info about orbitals	# of parts to orbital (Sub orbitals)	# of $e^-$ in sub	total # of $e^-$	Shape
<u>s</u>	<u>1</u>	<u>2</u>	<u>2</u>	sphere
<u>p</u>	<u>3</u>	<u>2</u>	<u>6</u>	propeller
<u>d</u>	<u>5</u>	<u>2</u>	<u>10</u>	

4 x spin

4 e<sup>-</sup> spin as they move e<sup>-</sup> spin

4 e<sup>-</sup> spin as they move e<sup>-</sup> spin  
↳ causes magnetism

S

4 e<sup>-</sup> spin as they move e<sup>-</sup> spin  
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5 Rules

4 e<sup>-</sup> spin as they move e<sup>-</sup> spin  
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5 Rules Aufbau Principle



4  $e^-$  spin as they move  $e^-$  spin  
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5 Rules Aufbau Principle  $e^-$  are added to atoms  
from low to high E

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5 Rules Aufbau Principle e<sup>-</sup> are added to atoms  
from low to high E

4s 4p 4d  
3s 3p 3d  
2s 2p  
1s

4 e<sup>-</sup> spin as they move e<sup>-</sup> spin  
↳ causes magnetism

5 Rules

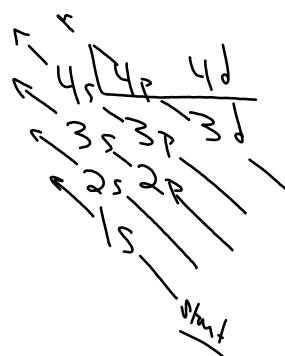
Aufbau Principle e<sup>-</sup> are added to atoms  
from low to high E  
↳ filling order

4s	4p	4d
3s	3p	3d
2s	2p	
1s		

4 $\pi$  spin as they move  $e^-$  spin  
 $\hookrightarrow$  causes magnetism

5 Rules

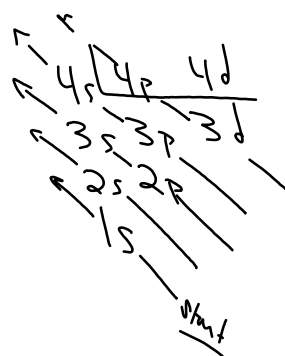
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Hund's Rule - 1  $e^-$  per suborbital  
B/f doubling

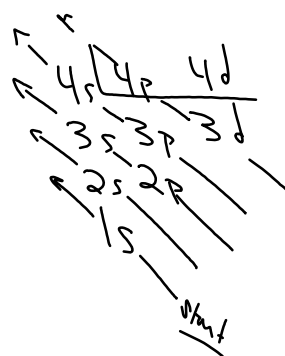


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Pauli Exclusion Principle

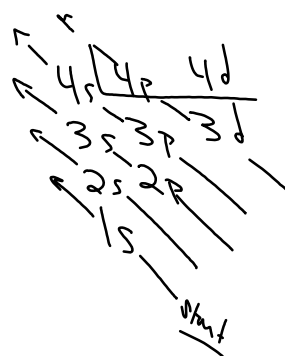


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Pauli Exclusion Principle - 2  $e^-$  can have same 4  
Quantum #'s.



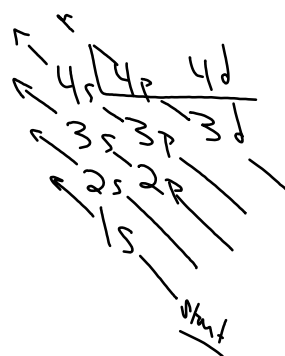
## Ch 4 Notes C Block.ink

4 e<sup>-</sup> spin as they move e<sup>-</sup> spin  
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## Ch 4 Notes C Block.ink

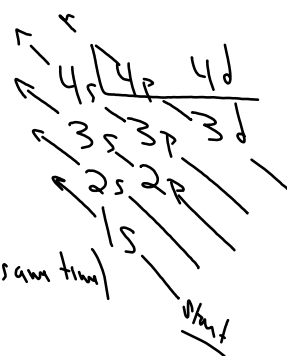
4  $e^-$  spin as they move  $e^-$  spin  
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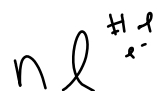
Pauli Exclusion Principle No 2  $e^-$  can have same 4

Quantum #s. (2  $e^-$  cannot be in same place & same time)

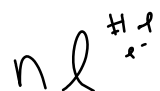


e-configuration notation

e- configuration notation



e- configuration notation

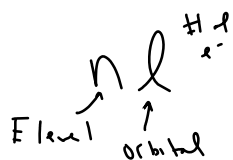


e- configuration notation



$n$   $l$   $H^+ l$   
 $e^-$   
 Element orbital

e- configuration notation



e- configuration notation

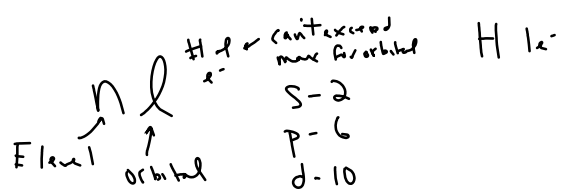
$n$   $l$   
↑ ↑  
Energy orbital  
 $H$   $l$   $e^-$  can't exceed  
max for orbital



e- configuration notation

$n$   $l$   $H \uparrow$   $e^-$  can't exceed  
max for orbital  
↑  
Element orbital  
S-2  
P-6  
d-10

e- configuration notation



e- configuration notation

e- config

Element  $n$   $l$   $H$   $l$   $e^-$  can exceed max for orbital  $H$   $1e^-$

orbital

S-2  
P-6  
d-10

e- configuration notation

$n$   $l$   
↑ ↑  
Energy level orbital

H  $l$  ← can't exceed max for orbital  
 $e^-$

S-2  
P-6  
d-10

H  $1s$  1s  
 $e^-$  config

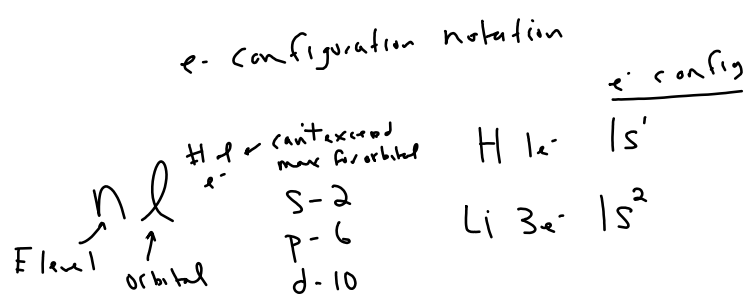
e- configuration notation

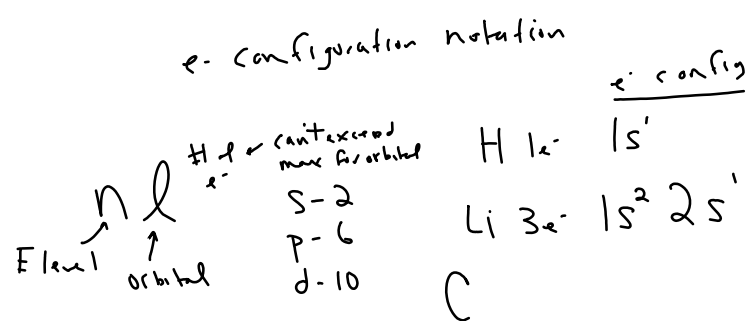
$n$   $l$   
↑ ↑  
Energy level orbital

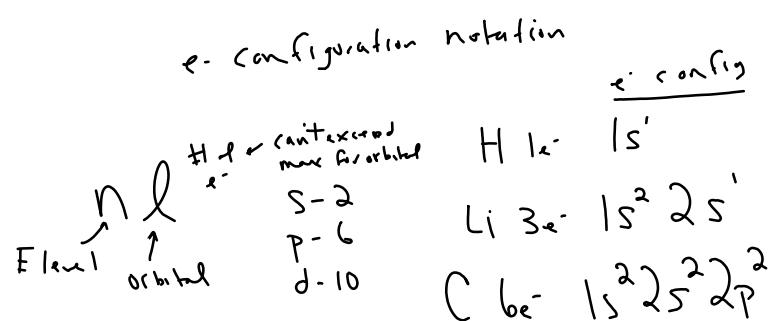
H  $l$  ← can't exceed max for orbital  
 $e^-$

S-2  
P-6  
d-10

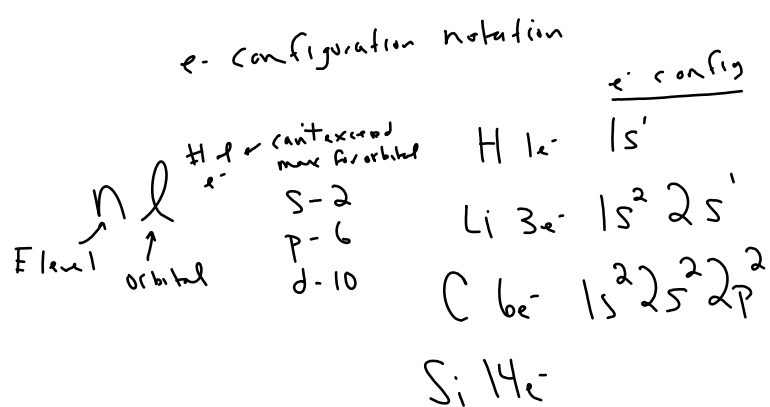
H  $1s^2$   $1s^1$   
e- config

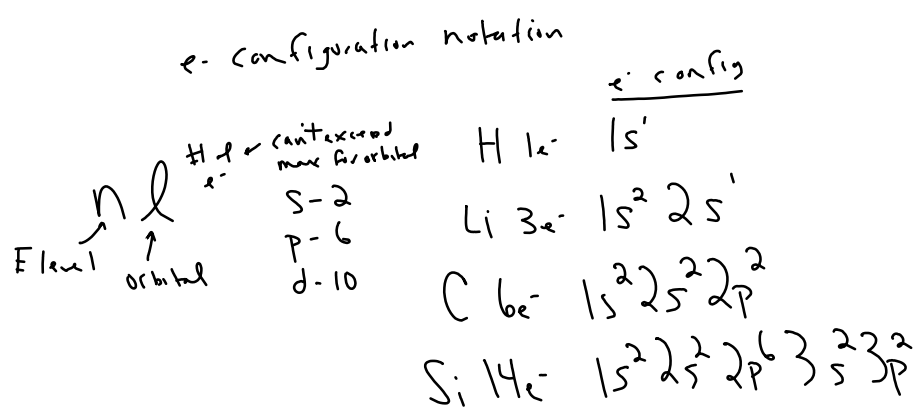












orbital notation

orbital notation

e. config Li  $\rightarrow 1s^2 2s^1$

orbital notation

↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning

$e^-$  config  $\text{Li} \rightarrow 1s^2 2s^1$

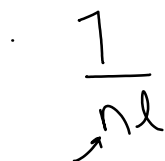
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$$\cdot \frac{1}{nl}$$

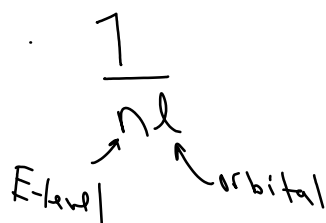
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### orbital notation

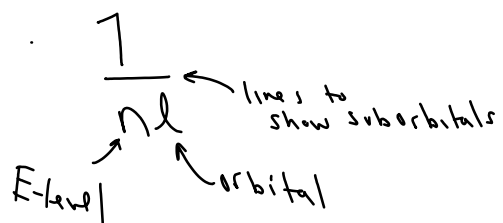
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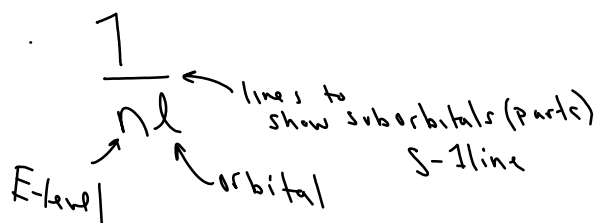
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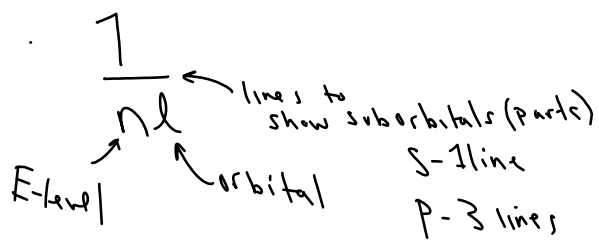
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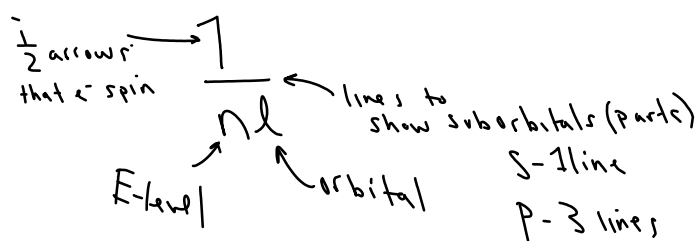
orbital notation

↑ notation  
↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning



### orbital notation

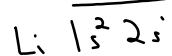
↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning



## orbital notation

↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning

$e^-$  config



$\frac{1}{2}$  arrow  
that  $e^-$  spin

E-level

$n$

orbital

lines to show suborbitals (parts)

S - 1 line

P - 3 lines

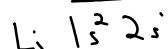
~

## orbital notation

↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning

$e^-$  config

orbital notation



$\frac{1}{2}$  arrows  
that  $e^-$  spin

E-level

$n, l$

lines to show suborbitals (parts)

orbital

S - 1 line

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## orbital notation

↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning

$e^-$  config

orbital notation

Li  $1s^2 2s^1$

$\overline{1s}$

$\frac{1}{2}$  arrow  
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$n, l$

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## orbital notation

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$e^-$  config  
Li  $1s^2 2s^1$

orbital notation  
 $\frac{1\downarrow}{1s}$

$\frac{1}{2}$  arrow  
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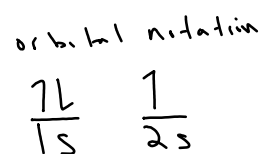
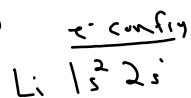
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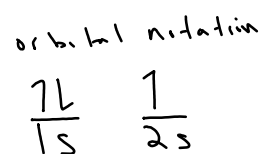
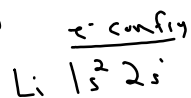


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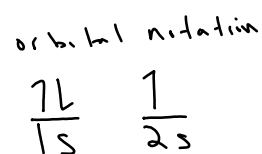
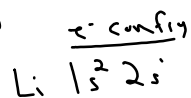
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## orbital notation

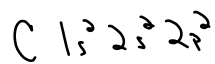
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$\frac{1}{2}$  arrow  
that  $e^-$  spin

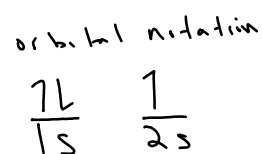
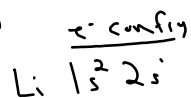
$n$   $l$   
↑  
E-level  
↑  
orbital

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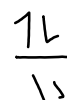
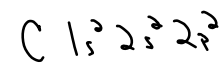
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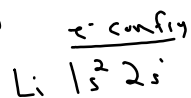


E-level

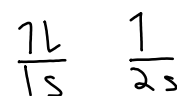
orbital

## orbital notation

↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning

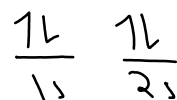
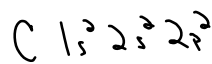


orbital notation



$\frac{1}{2}$  arrow  
that  $e^-$  spin

lines to show suborbitals (parts)  
S - 1 line  
P - 3 lines

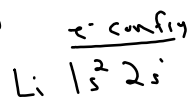


E-level

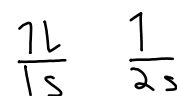
orbital

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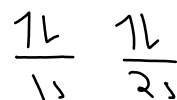
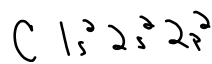


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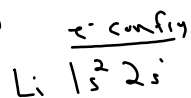


E-level

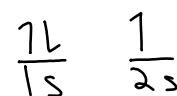
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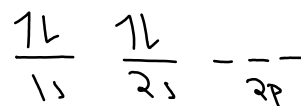
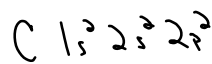


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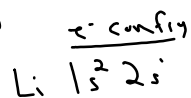


E-level

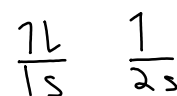
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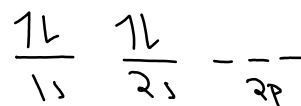
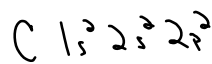


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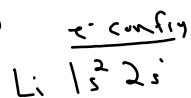
E-level

orbital

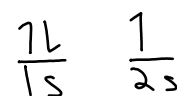


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↳ shows which sub-orbitals are filled and how the  $e^-$  are spinning

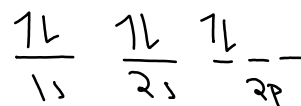
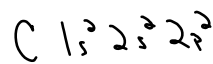


orbital notation



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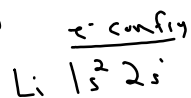


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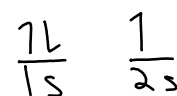
orbital

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orbital notation



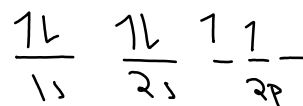
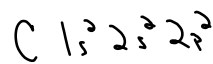
$\frac{1}{2}$  arrow  
that  $e^-$  spin

$n, l$   
↑  
E-level  
↑  
orbital

lines to show suborbitals (parts)

S - 1 line

P - 3 lines



Follow  
Hund's Rule

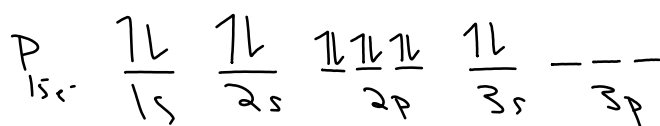
P  
15c-

$$P_{15\text{r}} \quad \frac{1L}{1S}$$

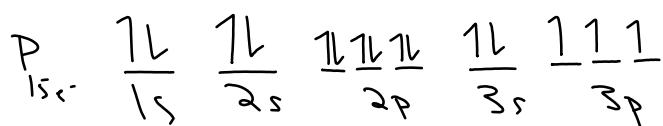
$$P_{15c} \quad \frac{1L}{1s} \quad \frac{1L}{2s}$$

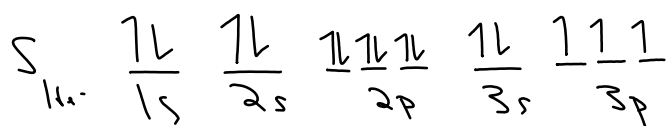
$$P_{15c} \quad \frac{1L}{1s} \quad \frac{1L}{2s} \quad \frac{1L}{2p} \quad \frac{1L}{2p} \quad \frac{1L}{2p}$$

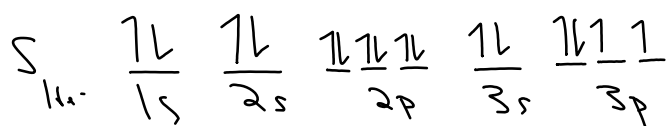
$$\begin{array}{ccccc} p & 1l & 1l & 1l & 1l \\ 1s & 1s & 2s & 2p & 3s \end{array}$$

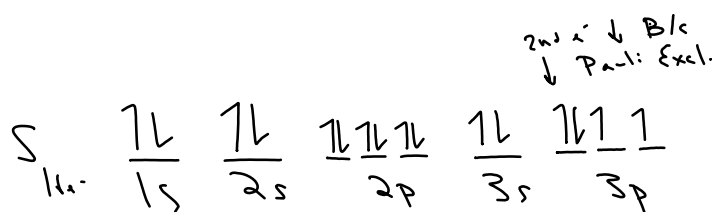


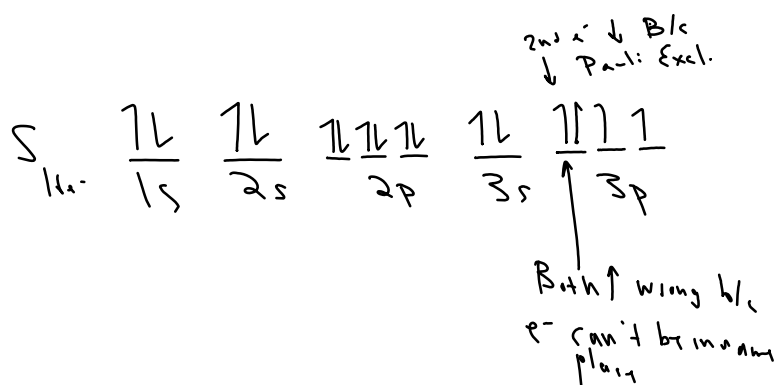


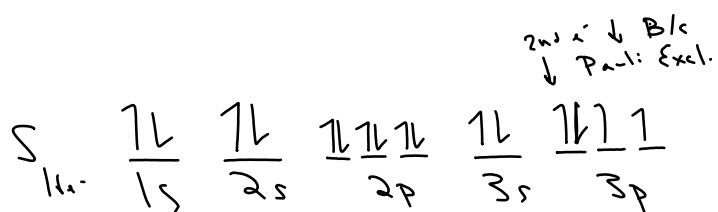












valence e<sup>-</sup> - outer shell e<sup>-</sup>

valence  $e^-$  - outer shell  $e^-$   
↳ highest E-level s+p  $e^-$



valence  $e^-$  - outer shell  $e^-$   
↳ highest E-level s+p  $e^-$   
↳ max of 8  $e^-$

valence  $e^-$  - outer shell  $e^-$   
↳ highest E-level s+p  $e^-$   
↳ max of 8  $e^-$

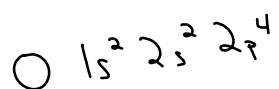
O

Mg

C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>  
↳ highest E-level s+p e<sup>-</sup>  
↳ max of 8 e<sup>-</sup>



Mg

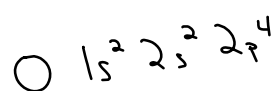
C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s + p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>



Mg

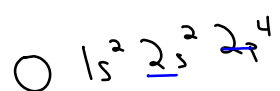
C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s+p e<sup>-</sup>

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Mg

C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s+p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>

○  $1s^2 \underline{2s^2} 2p^4$  6 val e<sup>-</sup> Mg

C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s+p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>

○  $1s^2 \underline{2s^2} 2p^4$  6 val e<sup>-</sup> Mg  $s^2 2s^2 2p^6 3s^2$

C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s+p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>

○  $1s^2 \underline{2s^2} 2p^4$  6 val e<sup>-</sup> Mg  $1s^2 2s^2 2p^6 \underline{3s^2}$  2 val e<sup>-</sup>

C

F



valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s+p e<sup>-</sup>

$$b_{\max} \propto \gamma e^{-}$$

○  $1s^2 \underline{2s^2} 2p^4$  6 valence

Mg

$s^2 2s^2 2p^6$  |  $3s^2$  2 val e<sup>-</sup>  
 inner shell | val e<sup>-</sup>  
 s<sup>-</sup>

C

F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s + p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>

○  $1s^2 \underline{2s^2} 2p^4$  6 val e<sup>-</sup> Mg  $\begin{array}{c|c} s^2 & 2s^2 2p^6 \\ \text{inner shell} & \end{array} \begin{array}{c} \underline{3s^2} \\ \text{val e}^- \end{array}$  2 val e<sup>-</sup>

○  $1s^2 2s^2 2p^2$  4 val e<sup>-</sup> F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s+p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>

○  $1s^2 \underline{2s^2} 2p^4$  6 val e<sup>-</sup>

He 1 → 1 val e<sup>-</sup>

Ne 2 → 2 val e<sup>-</sup>

Mg  $1s^2 \underline{2s^2} 2p^6$  3s<sup>2</sup> 2 val e<sup>-</sup>  
 inner shell | val e<sup>-</sup>

○  $1s^2 2s^2 2p^2$  4 val e<sup>-</sup> F

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s + p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>

○  $1s^2 \underline{2s^2} 2p^4$  6 val e<sup>-</sup>

Mg

$s^2 2s^2 2p^6 \underline{3s^2}$  2 val e<sup>-</sup>  
inner shell | val e<sup>-</sup>

○  $1s^2 2s^2 2p^2$  4 val e<sup>-</sup> F

Gr 1 → 1 val e<sup>-</sup>

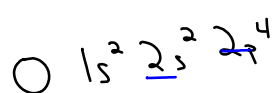
Gr 2 → 2 val e<sup>-</sup>

Gr 3-12 (d-block) - 2 val e<sup>-</sup>

valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s + p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>



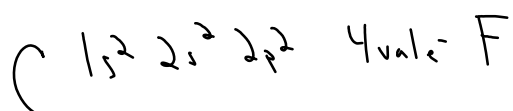
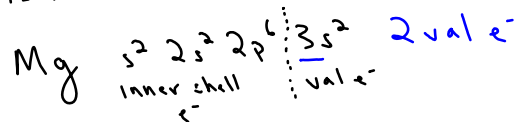
6 val e<sup>-</sup>

Gr 1 → 1 val e<sup>-</sup>

Gr 2 → 2 val e<sup>-</sup>

Gr 3-12 (d-block) - 2 val e<sup>-</sup>

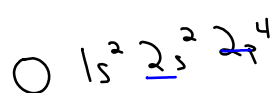
Gr 13-18 - val e<sup>-</sup> = Gr # - 10



valence e<sup>-</sup> - outer shell e<sup>-</sup>

↳ highest E-level s + p e<sup>-</sup>

↳ max of 8 e<sup>-</sup>



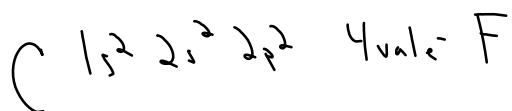
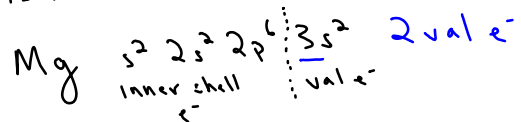
6 val e<sup>-</sup>

Gr 1 → 1 val e<sup>-</sup>

Gr 2 → 2 val e<sup>-</sup>

Gr 3-12 (d-block) - 2 val e<sup>-</sup>

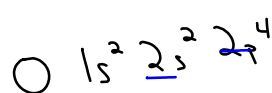
Gr 13-18 - val e<sup>-</sup> = Gr # - 10



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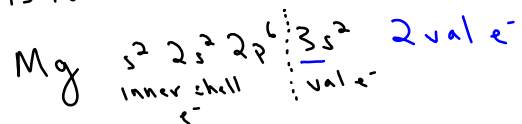
6 val e<sup>-</sup>

Gr 1 → 1 val e<sup>-</sup>

Gr 2 → 2 val e<sup>-</sup>

Gr 3-12 (d-block) - 2 val e<sup>-</sup>

Gr 13-18 - val e<sup>-</sup> = Gr # - 10



e- dot notation

↳ shows val e.  
as dots around the  
element's symbol



e- dot notation

↳ shows val e.  
as dots around the  
element's symbol

Specific Order

e- dot notation

↳ shows val e.  
as dots around the  
element's symbol

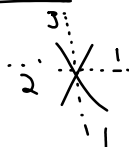
Specific Order

X

e- dot notation

↳ shows val e.  
as dots around the  
element's symbol

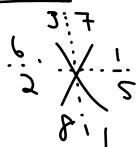
Specific Order



e- dot notation

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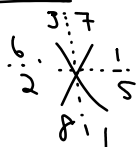
Specific Order



e- dot notation

↳ shows val e.  
as dots around the  
element's symbol

Specific Order



O

Mg

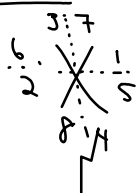
Al

F

e- dot notation

↳ shows val e.  
as dots around the  
element's symbol

Specific Order



O  
6

Mg

Al

F

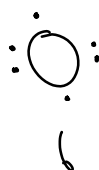
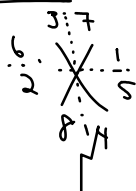
## Ch 4 Notes C Block.ink

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e- dot notation

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Specific Order



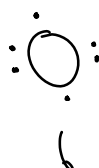
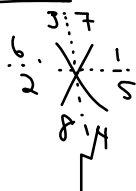
## Ch 4 Notes C Block.ink

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Specific Order

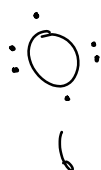
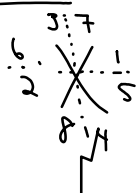




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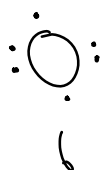
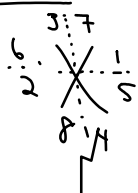
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